DETAIL JAPANESE

PATENT ABSTRACTS OF JAPAN

(11)Publication number : 07-198398
(43)Date of publication of application : 01.08.1995

(51)Int.Cl. G01C 19/72

(21)Application number : 06-012077
(22)Date of filing : 06.01.1994

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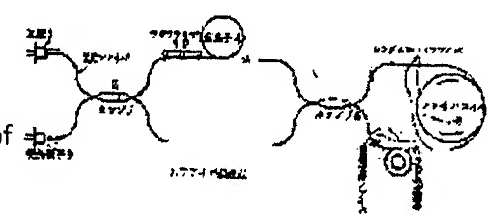
(54) OPTICAL FIBER GYRO, PHASE MODULATOR AND ITS MANUFACTURE

(57)Abstract:
PURPOSE: To reduce the number of depolarizers while a single-mode fiber is being used by a method wherein a polarization maintaining optical fiber is used as an optical fiber which is wound on a phase modulator.
CONSTITUTION: Light, from a light source 1, which is incident on an optical fiber 2 is passed through a coupler 3, and it is changed into nonpolarized light by a depolarizer 10 and into linearly polarized light by a polarizer 4. A beam of light, on one side, which is formed by branching it into two by a coupler 5 is passed clockwise through a fiber coil 6 by a single mode fiber, it is passed through a phase modulator 7, and it is returned to the coupler 5. A beam of light, on the other side, is passed through the modulator 7, it is passed counterclockwise through the coil 6, and it is united with the beam of clockwise light by the coupler 5. The beam of light is passed through the polarizer 4, it is changed into nonpolarized light by the depolarizer 10, and a photodetector 9 detects the beam of clockwise light and the interference optical intensity of the beam of counterclockwise light. It is synchronously detected by a phase- modulated synchronizing signal, and an output which is proportional to a phase difference is obtained. Since a polarization maintaining optical fiber is wound on the modulator 7 at this time, light is not polarization modulated by the modulator 7, and a depolarizer is not required near the coil 6.



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CLAIMS

[Claim(s)]
[Claim 1] Monochrome, the light source which generates quasi-monochromatic light, and a fiber coil around which a single mode fiber was wound about many times, A phase modulator which winds a fiber around the surroundings of a piezoelectric transducer, comes to carry out a time, and is formed in an end of a fiber coil, A coupler to which branch two and both ends of a fiber coil are made to carry out incidence of the light which came out of the light source, A photo detector which a fiber coil is made to interfere in ******** and detects reinforcement of an interference light is included. Inside of an optical fiber coil around which light which came out of the light source was wound about by coiled form The circumference of a clock, Light is made to spread to the circumference of an anti-clock, and a change of an interference light on the strength is detected by photo detector. Circumference light of a clock, An optical fiber gyroscope which is an optical fiber gyroscope which asks for the angular rate of rotation from phase contrast of circumference light of an anti-clock, and is characterized by using as polarization maintaining optical fiber an optical fiber twisted around a piezoelectric transducer of a phase modulator.
[Claim 2] Monochrome and the light source which consists of a light emitting device which generates quasi-monochromatic light, and a photo detector for monitors which supervises this quantity of light, A fiber coil around which a single mode fiber was wound about many times, and a phase modulator which winds a fiber around the surroundings of a piezoelectric transducer, comes to carry out a time, and is formed in an end of a fiber coil are included. Inside of an optical fiber coil around which light which came out of the light source was wound about by coiled form The circumference of a clock, Light is made to spread to the circumference of an anti-clock. A change of an interference light on the strength Drive current change of a light emitting device of the light source, Driver voltage change or photocurrent change of a photo detector for monitors detects. An optical fiber gyroscope which is an optical fiber gyroscope which asks for the angular rate of rotation from phase contrast of circumference light of a clock, and circumference light of an anti-clock, and is characterized by using as polarization maintaining optical fiber an optical fiber twisted around a piezoelectric transducer of a phase modulator.
[Claim 3] Monochrome, the light source which generates quasi-monochromatic light, and a fiber coil around which a single mode fiber was wound about many times, A phase modulator which winds a fiber around the surroundings of a piezoelectric transducer, comes to carry out a time, and is formed in an end of a fiber coil, A coupler to which branch two and both ends of a fiber coil are made to carry out incidence of the light which came out of the light source, A photo detector which a fiber coil is made to interfere in ******** and detects reinforcement of an interference light is included. Inside of an optical fiber coil around which light which came out of the light source was wound about by coiled form The circumference of a clock, Light is made to spread to the circumference of an anti-clock, and a change of an interference light on the strength is detected by photo detector. Circumference light of a clock, An optical fiber gyroscope which is an optical fiber gyroscope which asks for the angular rate of rotation from phase contrast of circumference light of an anti-clock, and is characterized by making an optical

fiber twisted around a piezoelectric transducer of a phase modulator into a single mode fiber twisted around an axis.

[Claim 4] Monochrome and the light source which consists of a light emitting device which generates quasi-monochromatic light, and a photo detector for monitors which supervises this quantity of light, A fiber coil around which a single mode fiber was wound about many times, and a phase modulator which winds a fiber around the surroundings of a piezoelectric transducer, comes to carry out a time, and is formed in an end of a fiber coil are included. Inside of an optical fiber coil around which light which came out of the light source was wound about by coiled form The circumference of a clock, Light is made to spread to the circumference of an anti-clock. A change of an interference light on the strength Drive current change of a light emitting device of the light source, Driver voltage change or photocurrent change of a photo detector for monitors detects. An optical fiber gyroscope which is an optical fiber gyroscope which asks for the angular rate of rotation from phase contrast of circumference light of a clock, and circumference light of an anti-clock, and is characterized by making an optical fiber twisted around a piezoelectric transducer of a phase modulator into a single mode fiber twisted around an axis.

[Claim 5] A phase modulator of a fiber mold characterized by twisting a single mode fiber around a piezoelectric transducer, and twisting an optical fiber twisted around a piezoelectric transducer in a fiber mold phase modulator which adds a phase modulation to light which a refractive index of an optical fiber is changed and spreads the inside of an optical fiber according to deformation of an optical fiber accompanying telescopic motion of a piezoelectric transducer.

[Claim 6] A manufacture method of a fiber mold phase modulator characterized by manufacturing a phase modulator by twisting around a piezoelectric transducer, letting out a portion which twists a fiber of an end of a fiber coil beforehand and was twisted.

[Claim 7] A manufacture method of a fiber mold phase modulator characterized by twisting a single mode fiber in the condition of having been twisted at a piezoelectric transducer while rotating a bobbin or a piezoelectric transducer for supply which twisted a single mode fiber.

[Claim 8] An optical fiber gyroscope which is an optical fiber gyroscope which is made to spread light for inside of an optical fiber coil wound around a coiled form about to the circumference of a clock, and the circumference of an anti-clock, and asks for the angular rate of rotation from phase contrast of circumference light of a clock, and circumference light of an anti-clock, and is characterized by forming one form birefringence medium in an edge in the middle of a fiber coil.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the optical fiber gyroscope which measures the angular rate of rotation of movement objects, such as an automobile, an airplane, and a vessel. It is related with the optical fiber gyroscope which uses as a fiber coil the single mode fiber which can remove the depolarizer used as the factor which pushes up especially a manufacturing cost.
[0002]
[Description of the Prior Art] The conventional optical fiber gyroscope has a configuration as shown in drawing 2 . This is the fundamental configuration of an optical fiber gyroscope. It may be called Minimum Configuration. It is because it was thought that it was the minimum configuration for functioning as an optical fiber gyroscope. Incidence of the monochrome and quasi-monochromatic light which came out of the light source 1 is carried out to the edge of an optical fiber 2, they pass a coupler 3, and pass along a polarizer 4. It becomes the linearly polarized light here. This branches through a coupler 5 and goes into the both ends of the fiber coil 6.
[0003] Such light turns around the fiber coil 6 as the circumference light of a clock, and a circumference light of an anti-clock. This passes a coupler 5 to the opposite sense, passes along a polarizer 4 and a coupler 3, and goes into a photo detector 9. When the fiber coil is rotating, the phases of the circumference light of an anti-clock and the circumference light of a clock differ. Phase contrast is proportional to the angular rate of rotation. A phase modulator 7 is formed in the end of the fiber coil 6. The light which passes through this receives a phase modulation. Since the time of day which receives a phase modulation is different with the circumference light of a clock, and the circumference light of an anti-clock, the effect remains and the output of a photo detector comes to include all the higher harmonics of phase modulation frequency. A synchronous detection is carried out and it asks for the magnitude of a fundamental wave. A fundamental wave has the magnitude proportional to phase contrast. The angular rate of rotation of a fiber coil is called for by this.
[0004] If all of a fiber coil or the fiber of a coupler and others are plane-of-polarization maintenance optical fibers, it is good with this configuration. However, if all optical paths are made from an expensive plane-of-polarization maintenance optical fiber, it will become the optical fiber gyroscope of an expensive frame extremely. A fiber coil, a coupler, etc. are the things of an optical path which want to almost make all from a cheap single mode fiber. Then, a cheap optical fiber gyroscope can be offered. However, to use a single mode fiber, as shown in drawing 3 , it is necessary to insert depolarizers 10 and 11 into an optical path.
[0005] A depolarizer is a device which changes the incident light of any polarization conditions into no polarizing. a depolarizer -- one -- or two are required. There is also a case of only the depolarizer 11 near the fiber coil 6. Furthermore, a depolarizer 10 may be put in also between the light source 1 and a polarizer 4. It is supposed that it is the purpose which puts in a depolarizer stabilizing the optical level which penetrates a polarizer. If it is made no polarizing by the depolarizer, the one half of the total quantity of light can penetrate a polarizer. Even if a polarization condition changes on the way, the amplitude of the light included in a photo detector

should not change in an operation of a depolarizer. Therefore, it is said that the level of the light which returns to a photo detector can be stabilized. However, that is not right in practice. Even if there is a depolarizer 11 in a fiber coil and there is nothing, a polarization condition does not change not much a lot. It is common. The reason is considered as follows.

[0006] ** If it becomes a fiber coil even if it is a single mode fiber, an anisotropy will arise in the direction of a right angle in a direction and this with curvature. A fiber coil wears form birefringence on a sake.

[0007] ** I hear that the light source used for an optical fiber gyroscope is the large light source of a luminescence wavelength range, and there is. Since coherence length is long, the monochromatic high light source becomes causes, such as a drift. Then, coherence length uses the short light source in many cases. When it does so, it comes to have not monochrome but breadth with luminescence wavelength.

[0008] ** In order to depend for the phase contrast between the cross polarization after passing a birefringence medium on wavelength, when incidence of the large light source of a wavelength range is carried out, phase contrast is distributed widely. On the other hand, the phase contrast between cross polarization becomes composition of various polarization conditions in order to determine the ovality of polarization. Therefore, a DEPORA rise will be carried out substantially.

[0009] It comes out, and since it is, in fact, stabilization of the quantity of light which passes along a polarizer is to make a drift small rather than it has an operation of a depolarizer. Explanation will be required since it is seldom recognized about this point. Then, the effect affect the drift of a depolarizer next is explained.

[0010] A phase modulator is needed in the optical fiber gyroscope of a phase modulation system. A phase modulator is constituted by twisting an optical fiber around a piezoelectric transducer like drawing 4 . The thing of a piezoelectric transducer of the shape of cylindrical and a cylinder is common. An electrode is prepared in an end face or an inside-and-outside peripheral surface, and it enables it to impress voltage. An optical fiber is twisted around the cylinder of a piezoelectric transducer, or a cylindrical side periphery. If voltage is impressed, a piezoelectric transducer expands and contracts according to the piezo-electric effect. Stress occurs in the optical fiber twisted in connection with this. The refractive index of a fiber changes with stress. Change of a refractive index changes the phase of the light which has spread this. If the alternation electric field of frequency omega are applied, it will change periodically [change of the phase of light] by omega. In this way, the phase modulation can be applied.

[0011] In such a phase modulator, the stress which joins an optical fiber is not axial symmetry. That is, the stress of a direction parallel to the cylinder side of the fiber wound around the cylinder differs from the stress of a direction right-angled to a cylinder side. Most parallel stress is 0. There is stress in the right-angled direction. Since the stress of non-axial symmetry works, a birefringence arises on a fiber. A birefringence is the phenomenon in which refractive indexes differ to the linearly polarized light which intersects perpendicularly. Moreover, the difference of a refractive index may be called birefringence. If it does so, a birefringence will vibrate synchronizing with a phase modulation. Consequently, the light which passed the phase modulator will receive not only a phase modulation but a polarization modulation.

[0012] With the optical fiber gyroscope of a phase modulation system, it is asking for the angular rate of rotation from the reinforcement of the lightwave signal (the component of frequency omega: fundamental wave) which synchronized with phase modulation frequency. The fundamental wave which gives the angular rate of rotation is called a signal component. While the fiber coil is standing it still, a fundamental-wave component is 0. It is assumed that the same frequency component as phase modulation frequency is contained in a lightwave signal in addition to a signal component. Fluctuation of this component generates a drift. Supposing a polarization modulation takes place for a phase modulator, the quantity of light which passes the polarizer prepared in the middle of the fiber will be changed synchronizing with a polarization modulation. Since this serves as fluctuation on the same frequency as the phase modulation frequency of the quantity of light included in a photo detector, a drift produces it.

[0013] A depolarizer has the operation which oppresses a polarization modulation. A depolarizer changes the light of the polarization condition of arbitration into no polarizing. It will be no

polarizing, if a depolarizer is passed even if it is the light of what kind of polarization. Even if it is the light in which polarization is changed in time, when a depolarizer is passed, it is no polarizing and a polarization condition stops changing in time. Even if a polarization modulation is carried out by passing along a phase modulator in a sake, a depolarizer negates a polarization modulation. A depolarizer can reduce a drift. This is the drift reduction effect by the depolarizer. A depolarizer has the operation which inhibits the polarization modulation which a phase modulator causes in this way rather than stabilizes the quantity of light which passes a polarizer. It is thought that such an operation is hardly recognized conventionally.

[0014] The problem explained above constitutes a fiber optical path by the single mode fiber. What was constituted with polarization maintaining optical fiber does not have such a problem. When making a fiber coil from polarization maintaining optical fiber, also as for the optical fiber which twists around a piezoelectric transducer and constitutes a phase modulator, it is common to use polarization maintaining optical fiber. Even if the stress of non-axial symmetry is added, a polarization modulation does not generate polarization maintaining optical fiber for the polarization maintenance capacity. For this reason, in the case of the optical fiber gyroscope which constitutes an optical path with polarization maintaining optical fiber, a depolarizer is unnecessary.

[0015]

[Problem(s) to be Solved by the Invention] In the optical fiber gyroscope which constitutes a fiber coil and a fiber optical path using a single mode fiber, in order to lose the drift of an output, the depolarizer was indispensable.

[0016] A depolarizer is made by joining the form birefringence medium whose thickness is two of 1:2 so that a main shaft may incline 45 degrees. The thickness of a medium needs to be larger than the value which broke the coherence length of the light source by the birefringence. A form birefringence crystal may be used. In the case of an optical fiber gyroscope, two polarization maintaining optical fiber is connected so that a main shaft may incline 45 degrees, and it uses it as a depolarizer.

[0017] This is shown in drawing 5 . Where polarization maintaining optical fiber Lb is twisted 45 degrees, it has connected with polarization maintaining optical fiber La. Manufacture of such a depolarizer is not easy. Great time amount is required compared with connection of the usual fiber. It is necessary to only connect two polarization maintaining optical fiber, but to connect in the condition that main shafts differ 45 degrees. A fiber is compared, light is put in, a fiber is rotated and the polarization condition of outgoing radiation light is measured. When it is not desired polarization, a fiber is rotated further and polarization of outgoing radiation light is investigated. Two fibers are connected when outgoing radiation light turns into desired polarization.

[0018] Thus, it is necessary to look for 45 torsion relation, adjusting whenever [angular relation / of an abutting surface]. For this reason, connection of the polarization maintaining optical fiber for a depolarizer requires great time amount. A depolarizer serves as an expensive optical element as a result. This makes the optical fiber gyroscope using a depolarizer expensive. Using a cheap single mode fiber, or it reduces a depolarizer, it is the purpose of this invention to offer the optical fiber gyroscope which can be set to 0.

[0019]

[Means for Solving the Problem] An optical fiber gyroscope of this invention is wound around a piezoelectric transducer etc. about where polarization maintaining optical fiber or a single mode fiber is twisted.

[0020] An optical fiber gyroscope of the 1st this invention is shown in [invention 1] drawing 1 . Incidence of the light which came out of the light source 1 is carried out to an edge of a single mode fiber 2, it passes along a coupler 3, passes a depolarizer 10 and a polarizer 4, goes into a coupler 5, and is divided into two beams. Each beam spreads the fiber coil 6 which consists of a single mode fiber as circumference light of a clock, and a circumference light of an anti-clock. A phase modulator 7 receives a phase modulation on the way. This passes along a coupler 5 and passes a polarizer 4 and a depolarizer 10 to opposite sense. Furthermore, it goes into a photo detector 9 from a coupler 3. A photo detector is an optoelectric transducer. It continues with

pre amplifier and a synchronous-detection circuit after this. Synchronizing with a signal of a phase modulator 7, the synchronous detection of the output of a photo detector is carried out, and a fundamental wave is searched for.

[0021] An optical fiber gyroscope of <A HREF="/Tokujitu/tjitemdrw.ipdl?N0000=239&N0500=1 E_N/;?8> 67 <67///&N0001=412&N0552=9&N0553=000003" TARGET="tjitemdrw"> drawing 1 is compared with an optical fiber gyroscope of drawing 3 . There are differences among two. I hear that the depolarizer 11 near the fiber coil 6 which suited drawing 3 first does not exist, and it is. Fiber coil of another is a single mode fiber, a phase modulator uses polarization maintaining optical fiber, I hear that a fiber coil is made by single mode fiber, and there is. Welding cementation of polarization maintaining optical fiber (birefringence fiber) and the single mode fiber is carried out on the way. One depolarizer can be reduced in this example.

[0022] An optical fiber gyroscope concerning other configurations of [invention 2] this invention makes a fiber twisted around a piezoelectric transducer a twisted single mode fiber. It does not only consider as a single mode fiber. It considers as a twisted single mode fiber. Appearance of a phase modulator is the same as that of drawing 4 . However, it is twisted where a single mode fiber is twisted. Usually, a fiber twisted around a piezoelectric transducer is the degree of a number turn - dozens turns. There should just be 360 ****** or more of a fiber between this overall length. of course -- an overall length -- 360 degrees or more -- it can twist and is good in ****.

[0023] thus, twist -- an optical fiber gyroscope which constituted a phase modulator by single mode fiber is the same configuration as drawing 2 , and does not interfere. However, although drawing 2 was previously explained as what was made from polarization maintaining optical fiber, all fiber optical paths are made from this invention by single mode fiber. A fiber coil and a phase modulator are single mode fibers. And a depolarizer is unnecessary.

[0024] How to twist around a piezoelectric transducer a single mode fiber [method [of twisting a fiber around the condition of having been twisted]] Twisted is explained. In order to make a phase modulator which twisted a torsion fiber, a fiber is once wound around a coiled form, a fiber coil is made, and it lets out an end of the fiber coil, and is made to twist around a side periphery of a piezoelectric transducer. In order to give torsion to a portion which a piezoelectric transducer rolls, there is a following method.

[0025] ** Twist a fiber of a portion of an end of a fiber coil beforehand, and twist this around the perimeter of a piezoelectric transducer. When it twists M times beforehand, a fiber wound around a piezoelectric transducer also has M times of torsion covering an overall length.

[0026] ** Don't twist an end of a fiber coil, but it twists a fiber, rotating a piezoelectric transducer centering on the direction of a fiber. That is, if the Z-axis is set as the direction of rolling up of a fiber, the axis of rotation of a piezoelectric transducer itself will be rotated around the Z-axis.

[0027] ** Twist an end of a fiber coil around the perimeter of a piezoelectric transducer, not twisting but rotating the fiber coil itself around the delivery direction of a fiber.

[0028] Using a single mode fiber, [means for drift reduction] this invention reduces a depolarizer, or loses it completely. For this reason, a method of winding polarization maintaining optical fiber around a piezoelectric transducer of it being twisted to a piezoelectric transducer and rolling a single mode fiber is used as mentioned above. A drift can be reduced now. In order to reduce a drift furthermore, it replaces with a depolarizer and a birefringence medium which has a big birefringence is formed in inside of a fiber coil, or an edge of a fiber coil. Polarization maintaining optical fiber can be used as a birefringence medium.

[0029]

[Function] An operation of the optical fiber gyroscope shown in [optical fiber gyroscope which made phase modulator with polarization maintaining optical fiber] drawing 1 is explained. The phase modulator is what twisted polarization maintaining optical fiber around the piezoelectric transducer. Since an anisotropy is in stress or a refractive index, polarization maintaining optical fiber saves the polarization condition of light. When the phase modulator is being made from this, a polarization modulation does not take place. Only a phase modulation happens ideally. Therefore, the drift resulting from the polarization modulation described previously does not

happen. In order to suppress a drift, the depolarizer was needed with the conventional single mode fiber mold optical fiber gyroscope. However, this invention already makes a depolarizer unnecessary. In drawing 1 , a depolarizer 11 is excluded, and the depolarizer 10 is drawn so that it may still exist. However, a depolarizer 10 can also be excluded.

[0030] [the optical fiber gyroscope which was twisted and made the phase modulator from the single mode fiber] -- this can also prevent the polarization modulation of the light by the phase modulator. Since a polarization modulation is controlled and a drift can be eliminated, a depolarizer can be excluded. However, there will be a question about the point why the phase modulator using a torsion fiber can control a polarization modulation. The problem [polarization / resulting from a phase modulator] of fluctuation itself is new, and the idea of controlling polarization fluctuation with a torsion fiber is also completely new. Then, this point is explained in detail.

[0031] The fiber currently wound around the piezoelectric transducer is a single mode fiber of axial symmetry. A drive of a phase modulator fluctuates the polarization of the light passing through this. Polarization fluctuation takes place. However, since the fiber is twisted, the polarization condition of outgoing radiation light differs from what is not twisted considerably.

[0032] [Polarization modulation in the condition that there is no torsion] in the conventional phase modulator which twisted the single mode fiber around the piezoelectric transducer first without twisting, I will explain how a polarization modulation occurs. Since it is easy, a birefringence when the piezoelectric transducer is standing it still is removed. Only the birefringence in which induction is carried out by the stress generated on the fiber by the piezoelectric transducer having expanded and contracted is made an issue of.

[0033] If incidence of the linearly polarized light is carried out to a medium with a birefringence, the light after passing a medium will turn into elliptically polarized light. The ovality at this time is dependent on the rate of a birefringence of a medium, and the length of an optical fiber. An ovality also calls it eccentricity here and 1 (a2-b2) / 2 / a defines from the major axis a and minor axis b of an ellipse. The overall length of a birefringence medium is divided into the minute sections 1, 2, and 3 and -- like drawing 6 . Since what is a birefringence medium from the first was divided, the minute section can be considered to be a thin phase plate. The main shaft of a birefringence can be assumed to these phase plates. This is a direction which a piezoelectric transducer expands and contracts. Since it is not twisting, in every phase plate, the main shaft of a birefringence has turned to the same direction. That is, the main shaft of elliptically polarized light is common in every minute section. Therefore, whenever the linearly polarized light passes along a phase plate, an ovality will fall. And the circular polarization of light is approached gradually.

[0034] If the linearly polarized light advances a birefringence medium, an ovality will decrease and the circular polarization of light will be approached. This means that the polarization component which intersects perpendicularly with the linearly polarized light of a basis increases gradually, and has it. The magnitude of this cross polarization component can estimate the magnitude of a polarization modulation. Supposing the first linearly polarized light is polarizing in the direction of X, cross polarization is the direction component of Y. The polarization component of a basis decreases as an orthogonal component increases. Even if a polarization condition changes, energy does not necessarily change in itself. However, since this passes along a polarizer, luminous energy will change depending on a polarization condition. Then, a drift happens.

[0035] it passes along a phase plate -- ** -- this rate is fixed, although it is alike, an ovality decreases and the circular polarization of light is approached -- a thing . The rate of reduction in an ovality changes with angles which the main shaft of the birefringence of a phase plate and the shaft of polarization of light make. Decline in the ovality of elliptically polarized light is the most remarkable, and the time of making the angle the main shaft of elliptically polarized light and whose birefringence main shaft of a phase plate are 45 degrees has the remarkable component change between cross polarization. When the fiber is not twisted, it is the assumed minute phase plate and degree of polarization changes in the same direction. Bearing of the shaft of the incidence polarization to the Mth phase plate is decided by the weak birefringence of the phase plate till then to the M-1st. However, this is remarkably changed with environmental

temperature. The condition of incidence polarization of a phase plat is changed by change of temperature to a sake. Since there is a temperature change considerably in the actual service condition of an optical fiber gyroscope, a polarization condition changes.

[0036] Next, the polarization condition in the twisted optical fiber is considered. The light which spreads the inside of the twisted fiber advances rotating polarization so that the torsion of a fiber may be followed. Although it is not the torsion angle itself, polarization rotates in proportion to a torsion angle. Rotation of the polarization by the torsion of a fiber changes with the location of a fiber. However, the direction of a birefringence is fixed. The fiber is wound around the surroundings of a piezoelectric transducer, and since it is the birefringence generated by the difference in the stress of radial and shaft orientations, a direction is fixed. For this reason, the angular relation which the major axis of the elliptically polarized light which carries out incidence to each phase plate (what divided the fiber into minute length virtually), a minor axis, and the main shaft of a birefringence make differs little by little in a travelling direction. Although changing elliptically polarized light is the angle which the main shaft of an ellipse and the main shaft of a birefringence make, this changes for every section.

[0037] If the fiber is not twisted, the direction of a main shaft of elliptically polarized light is eternal about the travelling direction of light. The angle which the shaft of a birefringence and the shaft of elliptically polarized light make to a sake is fixed. Occasionally this angle may be 45 degrees. Therefore, change of polarization is increasing steadily in proportion to the distance which advances the inside of a fiber. It will not interfere, if change of this polarization is fixed. However, this changes with temperature fluctuation. Since this causes a drift, it is a problem. Since this invention is twisting the fiber, the shaft orientation of elliptically polarized light and a birefringence is periodically changed according to advance of light. If the angle by the torsion of a fiber is pi/2 or more, there is a place which the relation between bearing of a birefringence and bearing of elliptically polarized light reverses. Then, change in the polarization condition of going to the elliptically polarized light by the birefringence of a fiber takes place to the opposite sense. If a torsion angle is the integral multiple of pi, the polarization change by the birefringence of a fiber will be negated completely. Though a torsion angle cannot be the integral multiple of pi, polarization change is only generated from the length of the gap from pi. The polarization fluctuation as the whole is very small to a sake. Since the original change is small, change of the polarization condition by temperature is also very small. The effect by the torsion of a fiber is in the place referred to as negating the polarization change by the birefringence of a fiber in this way.

[0038] It is desirable to put a birefringence medium into the end of a fiber coil further in this invention while being a fiber coil. For example, a birefringence crystal, polarization maintaining optical fiber, etc. are put in. This does not have relation with the direct polarization modulation by the phase modulator. However, it is effective when controlling a drift. It is made for the product of length L of the rate B of a birefringence and a fiber of a birefringence medium to be more than coherence length Lc of the light source. It is BL>Lc. Since the difference of the optical path length between cross polarization is more than coherence length, even if polarization rotates the light of these polarization 90 degrees, it does not interfere henceforth. The drift of an output decreases in a sake.

[0039]

[Example] Drawing 1 starts the 1st example of this invention. This optical fiber gyroscope consists of the light source 1 and the couplers 3 and 5 which generate monochrome and quasi-monochromatic light, a polarizer 4, the fiber coil 6 around which the single mode fiber was wound about many times, a phase modulator 7 which twisted polarization maintaining optical fiber around the piezoelectric transducer, and a photo detector 9 which detects the reinforcement of an interference light. The light which came out of the light source 1 carries out incidence to an optical fiber 2, passes a coupler 3, and results in a depolarizer 10. After being no polarizing here, it goes into a polarizer 4 and changes to the linearly polarized light. This becomes two branching light with a coupler 5. One beam passes through the fiber coil 6 of a single mode fiber as a circumference light of a clock. This returns to a coupler 5 through a phase modulator 7. The beam of another side passes along a phase modulator 7 previously, and, subsequently passes

through a fiber coil as a circumference light of an anti-clock. The circumference light of a clock and the circumference light of an anti-clock coalesce with a coupler 5, pass along a polarizer 4 in the opposite sense, turn into no polarizing by the depolarizer 10, and result in a photo detector 9 from a coupler 3. A photo detector 9 detects the reinforcement of the interference light of the circumference light of a clock, and the circumference light of an anti-clock. If the synchronous detection of this is carried out by the signal which synchronized with the phase modulation, the output proportional to the difference of a phase will be obtained.
[0040] In this structure, I hear that the optical fiber wound around the phase modulator is polarization maintaining optical fiber, and that it is new has it. Although a piezoelectric transducer moves to radial for a phase modulation and stress changes, since form birefringence is in the shaft orientations which became settled from the start, the polarization condition of light does not change. Light does not receive a polarization modulation in a sake with a phase modulator. For this reason, the depolarizer 11 which was near the fiber coil can be excluded. Drawing 7 shows the 2nd example of this invention. The light source 1, a polarizer 4, couplers 3 and 5, the fiber coil 6, a phase modulator 7, a photo detector 9, polarization maintaining optical fiber 13, etc. are included. A fiber coil rolls a single mode fiber about many times. This optical fiber gyroscope has two features. One is a phase modulator 7 and another is having put in polarization maintaining optical fiber 13.
[0041] The new feature of a phase modulator 7 is explained. This twists a single mode fiber around a piezoelectric transducer in the condition of having twisted in the direction of an axis. In order to carry out like this, there are three methods. A single mode fiber is wound around a fiber coil, and a part of this is rewound, this portion is twisted to the circumference of an axis, and it winds around the surroundings of a piezoelectric transducer in this condition. This is one method. Another is wound around a piezoelectric transducer, twisting around a piezoelectric transducer the edge of the fiber which has come out of the fiber coil, and rotating a fiber coil to the circumference of an axis. Or it winds around the surroundings of a piezoelectric transducer, rotating a piezoelectric transducer to the circumference of an axis.
[0042] The semantics of twisting a fiber is as having already explained. Although stress is periodically changed by the phase modulation and a birefringence is also changed periodically, since the direction of a birefringence will turn to various directions about polarization of light, polarization fluctuation is negated spatially. The count of torsion is decided by the length of a fiber coil etc. When the fiber length of a fiber coil is about 100m, it is necessary to twist 10 or more ******s. This is that the result of an experiment shows. Another feature is having inserted polarization maintaining optical fiber 13 near the fiber coil. Although a depolarizer joins two polarization maintaining optical fiber, this invention is enough if one polarization maintaining optical fiber is connected instead of a depolarizer. One polarization maintaining optical fiber is reducible. Moreover, although time amount starts and is very difficult for tuning finely and connecting so that birefringence shafts may differ 45 degrees, such actuation of this invention is unnecessary.
[0043] Polarization maintaining optical fiber is put in for making it the difference of the optical path length between cross polarization become more than the coherence length of the light source. By carrying out like this, interference does not take place between cross polarization. If coherence length of L and the light source is set [the rate of a birefringence of polarization maintaining optical fiber] to Lc for the length of B and a fiber, it is necessary to be BL>Lc. Since there are such conditions, as for the light source, it is desirable to use coherence length's short super luminescent diode. However, if the above-mentioned conditions are satisfied, even if it uses semiconductor laser, it will not interfere.
[0044] The depolarizer 11 near the fiber coil can be excluded with the optical fiber gyroscope of drawing 7 . However, the depolarizer 10 in front of a polarizer remains. Since a coupler 3 is in the path to a polarizer from the light source, there is **** to which a polarization condition is changed and the quantity of light included in a polarizer swings. The depolarizer 10 is put in in order to prevent this. When it carries out like this, no matter it may be in what polarization condition, it can let the light of half power pass to a polarizer. The light energy which penetrates a polarizer is stabilized. This invention cannot give the amelioration which makes this depolarizer

unnecessary directly.
[0045] Drawing 8 is the optical fiber gyroscope which applied this invention to the "optical fiber gyroscope which takes a signal from the light source" (Japanese Patent Application No. No. 260662 [four to], Japanese Patent Application No. No. 57756 [five to]) which this invention person cut and invented. This optical fiber gyroscope does not have the photo detector of dedication. The coupler 3 which branches a photo detector and a light emitting device to a sake is also unnecessary. In drawing 8 , an optical fiber gyroscope contains the light emitting device which generates the light of monochrome and semi- monochrome, and the photo detector for monitors which supervises the quantity of light of a light emitting device. The light emitting device + photo detector is called light source. The light which came out of the light source 1 turns into the linearly polarized light with a polarizer 4, and branches in two light with a coupler 5. One side passes along polarization maintaining optical fiber 14, and rotates the fiber coil 6 to the circumference of a clock. Furthermore, a phase modulator 7 receives a phase modulation. Another side spreads the fiber coil 6 to the circumference of an anti-clock through a phase modulator 7 on the contrary, passes along polarization maintaining optical fiber 14, and results in a coupler 5. Two beams unite with a coupler 5, escape from a polarizer 4 on the contrary, and result in the light source 1. In the light source, the reinforcement of an interference light is detectable with change of the drive current of a light emitting device, change of driver voltage, or change of the photocurrent of a light emitting device. Also in this case, it is made what twisted the single mode fiber and twisted the phase modulator around the piezoelectric transducer. Or the optical fiber which constitutes a phase modulator is used as the polarization maintenance fiber. If it carries out like this, since the obstructive polarization modulation by the phase modulator will hardly take place, the depolarizer near the fiber coil can be excluded. Polarization maintaining optical fiber 14 is instead added near the fiber coil. It is made for this to also satisfy the conditions of BL>Lc. When the optical fiber which constitutes a phase modulator is polarization maintaining optical fiber, addition of polarization maintaining optical fiber 14 is also unnecessary.
[0046] Since the coupler 3 with which this method leads to a photo detector 9 is unnecessary, the light from the light source is directly connected to a polarizer. There is no **** to which a polarization condition is changed between them. A depolarizer 10 can be excluded to a sake. If it does so, both of depolarizers are omissible. A depolarizer can be excluded completely, using a single mode fiber.
[0047]
[Effect of the Invention] This invention proposes the optical fiber gyroscope using a single mode fiber with an unnecessary depolarizer for the first time. In the optical fiber gyroscope which used the single mode fiber for the fiber coil, a manufacturing cost can be pushed up and the depolarizer which obstructed the productivity drive can be abolished. The polarization maintaining optical fiber which constituted the depolarizer is reduced, and material cost is reduced. Since manufacture of a depolarizer with much adjustment actuation etc. becomes unnecessary, a manufacturing cost can also be reduced.

[Translation done.]

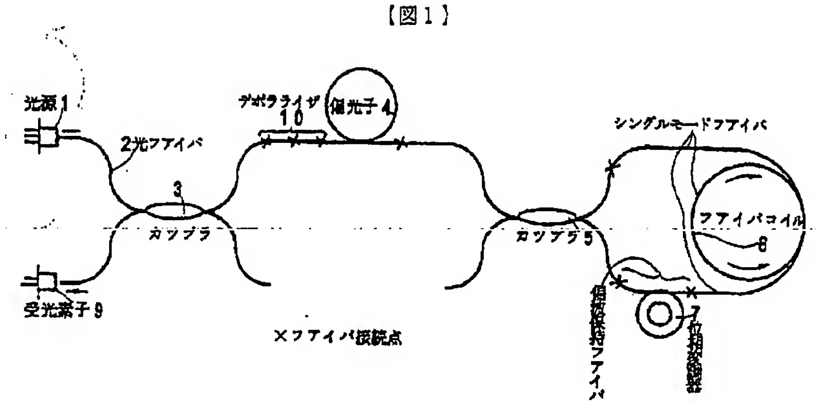
13

1 光源
2 光ファイバ
3 カップラ
4 偏光子
5 カップラ
6 ファイバコイル

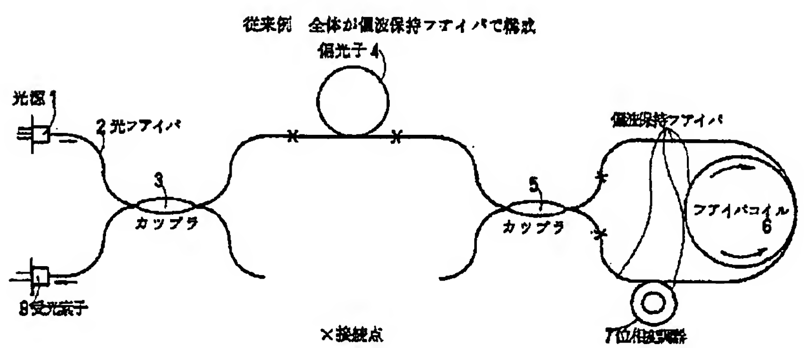
14

＊7 位相変調器
9 受光素子
10 デポラライザ
11 デポラライザ
13 偏波保持光ファイバ
＊ 14 偏波保持光ファイバ

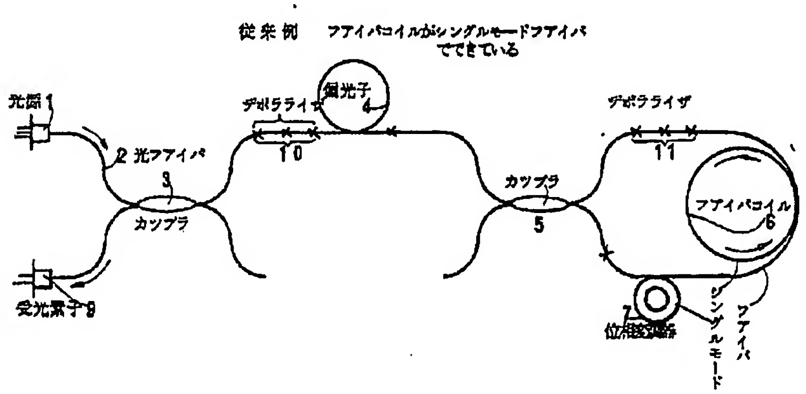
【図1】



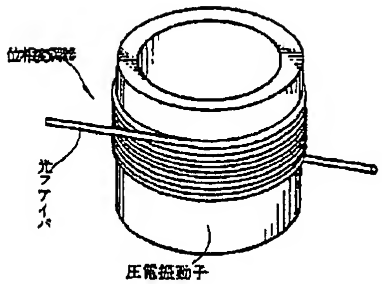
【図2】



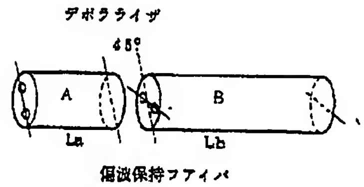
【図3】



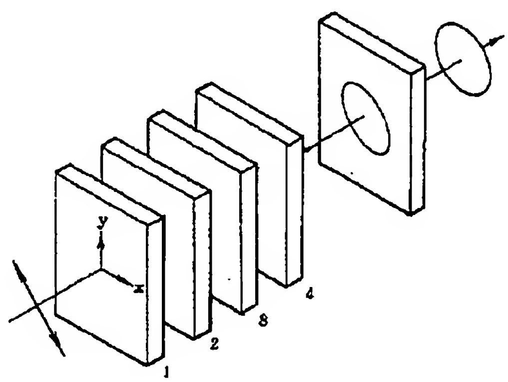
【図4】


位相変調器
光ファイバ
圧電振動子

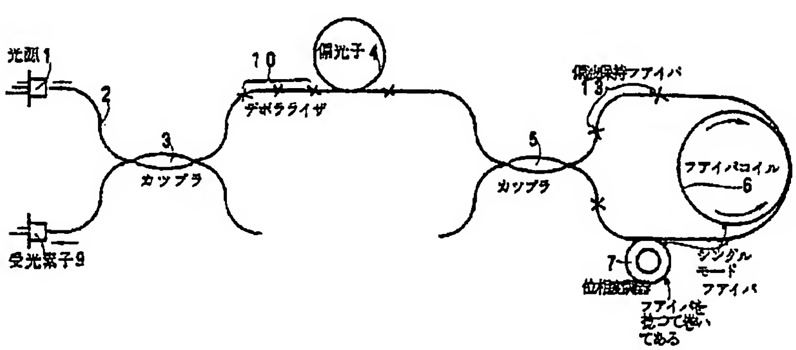
【図5】


デポラライザ
45°
A
B
La
Lb
偏波保持ファイバ

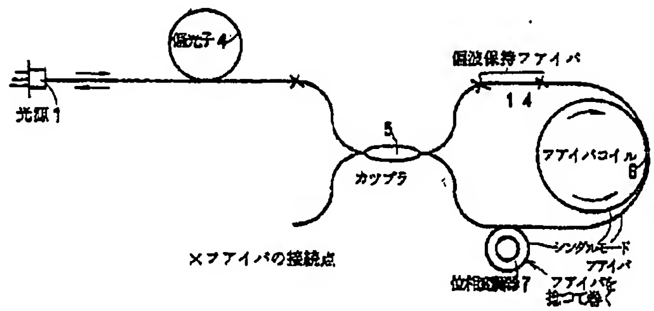
【図6】


y
x
1
2
3
4

【図7】


光源1
2
3
カップラ
10
デポラライザ
偏光子4
5
カップラ
偏波保持ファイバ
13
ファイバコイル
6
7
位相変調器
シングルモードファイバ
ファイバを捻って巻いてある
受光素子9

【図８】



光源１
偏光子４
偏波保持ファイバ
１４
５
カップラ
ファイバコイル
６
シングルモード
ファイバ
位相変調器７
ファイバを
捻って巻く
×ファイバの接続点

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] The block diagram of the optical fiber gyroscope of this invention.
[Drawing 2] The block diagram of the optical fiber gyroscope which used the polarization maintaining optical fiber concerning the conventional example for the fiber coil.
[Drawing 3] The block diagram of the optical fiber gyroscope which used the single mode fiber concerning the conventional example for the fiber coil, and prepared the depolarizer near the fiber coil the polarizer front.
[Drawing 4] The perspective diagram of the phase modulator which twisted the optical fiber around the piezoelectric transducer.
[Drawing 5] The decomposition perspective diagram of the depolarizer which joined two polarization maintaining optical fiber so that an anisotropy shaft might make 45 degrees.
[Drawing 6] The decomposition perspective diagram showing what considered as a set of a minute phase plate with the birefringence located in a line with a longitudinal direction in a fiber with a birefringence.
[Drawing 7] The block diagram of the optical fiber gyroscope concerning the example of this invention.
[Drawing 8] The block diagram of the optical fiber gyroscope concerning the example which applied this invention to the optical fiber gyroscope which takes out a signal from the light source which this invention person invented before.
[Description of Notations]
1 Light Source
2 Optical Fiber
3 Coupler
4 Polarizer
5 Coupler
6 Fiber Coil
7 Phase Modulator
9 Photo Detector
10 Depolarizer
11 Depolarizer
13 Polarization Maintaining Optical Fiber
14 Polarization Maintaining Optical Fiber

[Translation done.]